UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PHYSICAL, MECHANICAL AND MORPHOLOGICAL PROPERTIES OF RECYCLED POLYPROPYLENE (PP) REINFORCED WITH COCONUT FIBER

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DECLARATION

I declare that this Choose an item. entitled "Physical, Mechanical and Morphological Properties of Recycled Polypropylene (PP) Reinforced with Coconut Fiber" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical & Manufacturing Engineering Technology with Honours.

Signature	:	....
Supervisor Name	:	DR. YUSLIZA BINTI YUSUF
Date	:	28 JAN. 2022

DEDICATION

This study is wholeheartedly dedicated to our beloved parents, who have been our source of inspiration and gave us strength when we thought of giving up, who continually provide their moral, spiritual, emotional and financial.

To our brothers, sisters, relatives, mentor, friends and classmates who shared their words of advice and encouragement to finish this study

And lastly, i dedicated this book to the Almighty God, thank you for the guidance, strength, power of mind, protection and skills and for giving us a healthy life. All of these, we offer to you.

ABSTRACT

Polypropylene is a biodegradable thermoplastic polymer that is used in a wide number of applications. Due to the short shelf life of polypropylene-based packaging, the great majority of these thermoplastics end up in landfills as waste. Polypropylene goods degrade slowly in landfills, requiring between twenty and thirty years to completely degrade. This characteristic contributes significantly to environmental problems. Additionally, conventional filament materials for 3D printing are not recyclable. The fundamental objective of this research is to create a new biodegradable filament for 3D printing. The specific objective is to develop a filament material from a novel blend of recycled polypropylene and coconut fiber. To characterize the physical, thermal, and rheological properties of reinforced composites made of recycled polypropylene and coconut fiber. Although the Coconut Fiber was delivered in small pieces, it would through numerous processes before being sieved to 125 microns. Even if the Recycled Polypropylene is already in resin/pellet form, this process must be carried out to ensure that no foreign particles interfere with the compounding process. Polypropylene recycled has emerged in the form of resins. However, before beginning the mixing procedure, the resins must be washed and dried to ensure that they are clean and in good condition. Alkali (NaOH) was used to improve the tensile and flexural properties of coconut fiber while decreasing its impact strength. The alkali solution concentration utilized to treat the fiber varied between 0.5 and 28%, but the majority of researches used less than 10% alkali solution. 20–180°C and 15–48 hours are the temperatures and times used to treat the natural fiber in the solution, respectively. Weighing coconut fiber and recycled polypropylene will determine their fiber content. The extrusion process will be assisted by a double extruder machine. Both materials will be placed into the hopper of this machine. Several experiments have been conducted to determine the mechanical, physical, and morphological properties of coconut fiber filaments. Tensile testing, SEM analysis, and absorption testing were all performed. The data collected during the test have been recorded and analyzed.

ABSTRAK

Polipropilena ialah polimer termoplastik biodegradasi yang digunakan dalam pelbagai aplikasi. Disebabkan jangka hayat pembungkusan berasaskan polipropilena yang singkat, sebahagian besar termoplastik ini berakhir di tapak pelupusan sebagai sisa. Barangan polipropilena merosot secara perlahan di tapak pelupusan sampah, memerlukan antara dua puluh dan tiga puluh tahun untuk merosot sepenuhnya. Ciri ini menyumbang dengan ketara kepada masalah alam sekitar. Selain itu, bahan filamen konvensional untuk percetakan 3D tidak boleh dikitar semula. Objektif asas penyelidikan ini adalah untuk mencipta filamen biodegradasi baharu untuk percetakan 3D. Objektif khusus adalah untuk membangunkan bahan filamen daripada campuran baru polipropilena kitar semula dan sabut kelapa. Untuk mencirikan sifat fizikal, haba dan reologi bagi komposit bertetulang yang diperbuat daripada polipropilena dan serat kelapa kitar semula. Walaupun Sabut Kelapa dihantar dalam kepingan kecil, ia akan melalui pelbagai proses sebelum diayak kepada 125 mikron. Walaupun Polipropilena Kitar Semula sudah dalam bentuk resin/pelet, proses ini mesti dijalankan untuk memastikan tiada zarah asing yang mengganggu proses pengkompaunan. Polipropilena kitar semula telah muncul dalam bentuk resin. Walau bagaimanapun, sebelum memulakan prosedur pencampuran, resin mesti dibasuh dan dikeringkan untuk memastikan ia bersih dan dalam keadaan baik. Alkali (NaOH) digunakan untuk menambah baik sifat tegangan dan lenturan serat kelapa sambil mengurangkan kekuatan hentamannya. Kepekatan larutan alkali yang digunakan untuk merawat gentian berbeza antara 0.5 dan 28%, tetapi kebanyakan penyelidikan menggunakan larutan alkali kurang daripada 10%. 20–180 ° C dan 15–48 jam ialah suhu dan masa yang digunakan untuk merawat gentian semula jadi dalam larutan, masing-masing. Menimbang serat kelapa dan polipropilena kitar semula akan menentukan kandungan gentiannya. Proses penyemperitan akan dibantu oleh mesin penyemperit berganda. Kedua-dua bahan akan dimasukkan ke dalam corong mesin ini. Beberapa eksperimen telah dijalankan untuk menentukan sifat mekanikal, fizikal dan morfologi filamen sabut kelapa. Ujian tegangan, analisis SEM, dan ujian penyerapan semuanya dilakukan. Data yang dikumpul semasa ujian telah direkodkan dan dianalisis.

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Last but not least, I would to thank all my classmate for always support each other and keep sharing information and knowledge According to the Pandemic circumstances, completing this study is a little difficult, but with all support and advice, it is done very successfully. I'd also like to thank my dear parents for their unending love, support, and prayers. Finally, I'd like to express my gratitude to everyone who helped, supported, and inspired me to begin my studies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
%	-	Percent
C3H6	-	Cyclopropane
°F	-	Fahrenheit
°C	-	Celsius
g/cm	-	gram per cubic centimeter
cm	-	Centimeter
Mm	-	Millimeter
Tex	-	1 gram per 1000 meters
cN/tex	-	max tensile force / linear density
H2SO4	-	Sulfuric acid
Na2S	-	Sodium sulfide
Na2CO3	-	Sodium Carbonate
NaOH	-	Sodium hydroxide
N/mm2	-	Newton Per Square Millimeter
	-	

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Recycling is one of the most important acts that can be taken right now to address the environmental and ecological risks posed by decreasing oil usage, carbon dioxide emissions, and waste disposal volumes. Despite the fact that plastic recycling remains the most successful technique of reducing plastic waste, the quality of the material is influenced by polymer cross-contamination, additives, non-polymer contaminants, and deterioration. Polypropylene is unquestionably one of the most widely used plastic packaging materials on the planet.; nevertheless, only about 1% of it is recycled, implying that the vast majority of Polypropylene is destined for the landfill.

Bio-fibers are becoming increasingly popular as fillers and/or reinforcement in plastics-composites due to their processing flexibility, high specific properties, high specific stiffness, and lower volumetric cost. Furthermore, bio-based natural fiber composites are used to improve electrical resistance, mechanical characteristics, acoustic insulating qualities, and thermal properties, as well as fracture resistance and quality.

In order to minimize the abandon of Polypropylene in landfill, this study aims to develop the 3D Printing Filament material using Recycled Polypropylene (PP) and the Coconut Fiber used as reinforcement material.

1.2 Problem Statement

Polypropylene is a recyclable thermoplastic polymer that is widely utilized in a variety of products. Because of the short lifespan of Polypropylene-based packaging, the vast majority of these thermoplastics end up as garbage in landfills. Polypropylene products decay slowly in landfills, taking 20-30 years to totally dissolve. This trait raises serious environmental problems. Besides, the current 3D printing filament materials not recyclable. The two classic types of 3D printer filament, Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA), are not recycled by most curbside municipal recycling programs. Under the ASTM International Resin Identifier Codes, both are classified as Type 7, or “Other”, which are not typically processed by municipal programs (Williams, 2019).

Because a lot of the abandon Polypropylene waste and to reduce the rate of 3d filament disposal that cannot be recycled, this study is conducted to develop the biodegradable 3D printing filament material using recycled Polypropylene with coconut fiber as reinforced material.

1.3 Research Objective

The primary goal of this study is to produce a new biodegrable 3D printing filament. Specifically, the objective are as follows:

a) To characterized the physical and thermal properties of Recycled Polypropylene and Coconut Fiber as reinforced material.

b) To evaluate the effect of sodium hydroxide treatment on the Coconut fiber thermal properties.

c) To analyze the physical, mechanical and morphological properties of recycled polypropylene composite reinforced with Coconut fiber.

1.4 Scope of Research

- This study limit on using the coconut fiber as reinforcement material and recycled Polypropylene as a matrix in order to encounter the problem pollution in landfill because of the abandon Polypropylene.

- The preparation of Fiber involved clean, grind, sieve and sodium hydroxide as a treatment.

- In order to mix the composition of Recycled Polypropylene and Coconut Fiber, Twin Extruder machine will be used to produce a resins material.

- Thermal Analysis (TGA), Rheology and Scanning Electron Microscopy (SEM) will be used as the equipment to characterize the properties of Recycled Polypropylene and Coconut Fiber.

CHAPTER 2

LITERATURE REVIEW

2.1 Recycled Polypropylene

Mechanical recycling isolates polypropylene waste from different resin types, washes it to remove dirt and pollutants, grinds and crushes it to reduce particle size, and then heat extrudes and reprocesses it into new plastic items. Chemical recycling converts plastic garbage to its original monomers or other valuable compounds, whereas incineration generates energy (Van de Velde, 2002).

Mechanical and chemical recycling are the most common methods for dealing with polypropylene waste. The reuse and recovery rate of recycled polypropylene materials is crucial for the plastics sector, which is oil-dependent and has a detrimental impact on the environment and the economy (Matei et al., 2017). As a result, the amount of energy and raw resources (such as propylene) needed to produce new products is reduced, considerable amounts of raw materials are returned to the economic cycle, and the amount of polypropylene waste put in landfills or incinerators is also reduced (Matei et al., 2017).

2.1.1 New Polypropylene

Polypropylene is a polymer having the chemical formula C3H6 that is used to make plastics (Shubhra et al., 2013). It has a wide range of applications in both industry and consumer items, and it may act as both a structural plastic and a fiber. This plastic is often used in the production of food containers, particularly those that must be dishwasher safe. In comparison to many other polymers, polypropylene has a fairly high melting point of 320°F (160°C) (Shubhra et al., 2013).

In comparison, polyethylene, another typical container plastic, has a much lower melting point (Shubhra et al., 2013). While polypropylene is well-known for being lightweight and incredibly durable, the texture of the material varies depending on the polymerization technique employed. Isotactic polypropylene is a stiff polymer made up of methyl group atoms that are all bonded to one side of its atomic chain (Shubhra et al., 2013). Figure 2.1 Polypropylene's atomic chain.

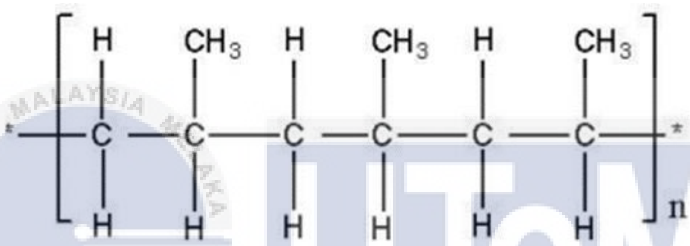

Figure 2.1 The atomic chain of Polypropylene

2.1.2 New Polypropylene Properties and Application

Polypropylene is a thermoplastic that is robust, stiff, and crystalline and is generated from the monomer propene (IAPD, 2014). The melting point of polypropylene is (160 - 165°C) for the homopolymer and (135 - 159°C) for the copolymer (IAPD, 2014). Polypropylene has high chemical resistance to diluted and concentrated acids, alcohols, and bases (Hisham A. Maddah, 2016a). Polypropylene is a highly combustible polymer with good resistance to environmental stress cracking (Hisham A. Maddah, 2016). Polypropylene keeps mechanical and electrical qualities when exposed to high temperatures, humidity, and submersion in water (Hisham A. Maddah, 2016).

Because of its chemical resistance and weldability, polypropylene is widely employed in a variety of applications. Polypropylene is a common packaging material. Because of its excellent barrier properties, high strength, smooth surface finish, and low cost, polypropylene is well suited for a wide range of packing applications (Hisham A. Maddah, 2016). Other applications include translucent parts, housewares, furniture, appliances, luggage, and toys. Because of properties such as high tensile strength, tolerance to high temperatures, and corrosion resistance, polypropylene sheets are commonly used in the industrial sector to manufacture acid and chemical tanks, sheets, and pipelines (Hisham A. Maddah).

Polypropylene is widely used in the automotive sector because of its low cost, high mechanical properties, and moldability (Hisham A. Maddah, 2016). Common applications include battery boxes and trays, bumpers, fender liners, interior trim, instrument panels, and door trims. Polypropylene fiber is utilized in many different products, including raffia/slit-film, tape, strapping, bulk continuous filament, staple fibers, spun bond, and continuous filament (Hisham A. Maddah, 2016). Polypropylene rope and twine are exceptionally strong and moisture-resistant, making them excellent for marine applications. Polypropylene is very commonly utilized in medicinal applications. Polypropylene is employed in a range of medical applications because to its superior chemical and microbiological resistance (Hisham A. Maddah, 2016).

2.1.3 Recycled Polypropylene Properties and Application

Each plastic has a Resin Identification/Plastic Recycling Code that is unique to the type of resin used. Polypropylene's resin identification code is 5. (Van de Velde, 2002). Polypropylene recycling is comprised of five steps: collection, sorting, cleaning, reprocessing, and new product manufacture (Van de Velde, 2002). Separate the polypropylene from the other plastic polymers first. This is achieved using a technique known as ‘sink float' separation, which is based on Polypropylene's unusual specific density (0.93•0.95g/cm), which allows it to float while other polymers, such as PET (specific density 1.43•1.45g/cm), sink (Van de Velde, 2002).

Polypropylene reprocessing begins with melting in an extruder at temperatures above 400 degrees Fahrenheit, followed by granulation for use in new manufacture (Van de Velde, 2002). Polypropylene ultimately degrades thermally, lowering the structural intensity of the plastic as the hydrogen-carbon bonds weaken (Van de Velde, 2002). To remove impurities, waste plastic is melted to 250 degrees Celsius, followed by vacuum extraction of remaining molecules and solidification at approximately 140 degrees Celsius (Van de Velde, 2002). This recycled polypropylene can be combined with virgin polypropylene up to 50%.

Recycled polypropylene can be found in packaging articles, automotive bumpers, foams, bottle caps, carpets, and home components, as well as straws and sweet wrappers. Bitumen concentrations of 2 to 5% by mass are typically preferred for bitumen asphalt applications (Bora et al., 2020). Recycled polypropylene can also be used as 3D printing filament.

2.1.4 Advantages and Disadvantages of Recycled Polypropylene

Polypropylene recycling can help reduce energy usage and pollutants in the air and water (Meran et al., 2008). Industrial waste generated by firms that manufacture plastics is now a substantial cause of pollution. Pollution can be considerably minimized if things are recycled rather than made from scratch on a regular basis (Meran et al., 2008). Polypropylene recycling also encourages appropriate plastics management and disposal (Meran et al., 2008).

Plastic manufacturing can entail the combustion of large volumes of trash, resulting in astonishing levels of greenhouse gas emissions (Meran et al., 2008). This involves recycling to reduce waste generation and maintain the burning process to a minimum. Converting garbage into useful and environmentally beneficial items would also help to reduce negative environmental impacts (Meran et al., 2008). Other advantages and cost reductions connected with recycling polypropylene include: Electronics, old water bottles, and other unwanted objects can be sold for money (Meran et al., 2008).

However, there are a few drawbacks to recycled polypropylene, such as increased pollution and energy usage (Meran et al., 2008). While this may appear to be paradoxical, recycling tonnes of garbage will necessitate waste being transported, sorted, cleaned, and processed in different facilities, all of which will take energy and may produce byproducts that contaminate the air, water, or soil. Furthermore, it may result in higher processing costs and lower-quality jobs (Meran et al., 2008). Recycling can be up to three times more expensive than landfilling rubbish (Meran et al., 2008). When recycling is not done properly, it can be harmful to both one's health and the environment (Meran et al., 2008). Not all